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ABSTRACT

The reference book is designed to fulfill the need for organized subject matter dealing with basic principles of animal science to be incorporated into the high school agriculture curriculum. The material presented is scientific knowledge basic to livestock production. Five units contain specific information on the following topics: anatomy and physiology of farm animals (nine physiological systems), nutrition of farm animals (feeds, nutrients, quality of protein, classification of feedstuffs, characteristics of concentrates, roughage and good ration, nutritional deficiencies, and feed additives), environmental factors that affect physiology (temperature, light, and moisture), diseases of farm animals (classification, causes, indicative physiological changes, and principles of control), and common parasites of farm animals (classification, life-cycles, economic importance, and principles of control). A question-answer format is used, with answers given in paragraph and outline form. (Author/MS)

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BASIC PRINCIPLES OF ANIMAL SCIENCE

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FOREWORD

In view of the broadened program in agricultural education to include "any occupation involving knowledge and skills in agriculture subjects", it is evident that basic principles must be taught during the first two or more years in the high school agriculture curriculum.

References that are concerned primarily with production practices are presently available to vocational agriculture teachers. This reference titled "Basic Principles of Animal Science" represents a different approach, and is designed to fulfill the need for organized subject matter dealing with basic principles. Much of the organized body of animal husbandry is deeply rooted in the basic principles of animal science. By bringing the two together — the WHY and the HOW — learning will be expedited and interest in performance will be increased. A comprehensive understanding of the basic principles underlying a procedure or practice, in connection with a problem, increases the efficiency of the individual, and equips him to make decisions on other problems involving the same or similar principles. Indeed, a practice taught without the understandings of the underlying basic principles will certainly not equip the students to adjust to a rapidly changing agriculture.

The best use of the basic principles seem to be this: Select and incorporate into the course of study those principles that are truly basic to agriculture and then "round out" the instruction by including productive enterprise jobs, improvement projects, supplementary practices, and other activities which can be worked into a supervised experience program to develop understandings and skills involved.

As already implied, it is <u>not</u> intended that basic principles be used to replace or de-emphasize the student's supervised experience program. Indeed, it is highly doubtful that basic principles can be effectively taught unless they are put into actual practice. Numerous experiences with the applications of these basic principles should result in the permanent and productive vocational education of our students.

Teachers are urged to supplement this reference with additional basic references, as long as they are reliable, and to use pictorials, specimens, films, filmstrips, and other visuals to make the information more meaningful.

We are greatly indebted to the Agricultural Education Department of Mississippi State University, and Mr. L. P. Jacks, Subject Matter Specialist, for permission to reproduce some of the materials in this publication.

TABLE OF CONTENTS

Unit		Page
I.	Anatomy and Physiology of Farm Animals	
	A. Skeletal System	3
	B. Muscular System	3
	C. Nervous System	4
	D. Circulatory System	4
	E. Respiratory System	7
	F. Excretory System	7
	G. Digestive System	8
	H. Sense Organs and Common Integument	10
	I. Reproductive System	10
II.	Nutrition of Farm Animals	23
III.	Environmental Factors That Affect Physiology	34
IV.	Diseases of Farm Animals	36
V.	Common Parasites of Farm Animals (Economics)	43

BASIC PRINCIPLES OF ANIMAL SCIENCE

I. Anatomy and Physiology of Farm Animals

The animal body is a highly complex structure which may be defined as: the living mechanism composed of systems of organs working harmoniously under the control of the nervous system, and capable of transforming, storing, and releasing energy. Each system is composed of a group of organs that perform a particular function. The organ systems of the body are:

A. Skeletal
B. Muscular
C. Nervous
D. Circulatory
E. Respiratory
F. Excretory
G. Digestive
H. Sense Organs and Common Integument
I. Reproductive

A. Skeletal System

1. What are the types of skeletal systems?

The animal kingdom is divided into two sub-kingdoms - the vertebrates, and the invertebrates. Vertebrates, are animals having a strong internal framework, or endo-skeleton. Invertebrates, are animals having an exo-skeleton type framework, such as insects, crayfish and a host of others. Our interest in this publication will deal only with the vertebrate sub-kingdom, which includes human beings, farm livestock, and poultry.

2. What are the functions of the skeletal system and how is it related to animal quality?

This system is composed of the bony and cartilage structures of an animal's body. It serves to support the other body systems, for protection, and acts as levers of motion. In addition, the bones through the medium of their red marrow manufacture the red-blood corpuscles, some forms of white blood corpuscles, and serve as a store house for minerals that is drawn upon when the body needs demand a supply.

The quality of the skeleton is closely related to an animal's health and quality. It should be well-developed and maintained through proper management of the animal in order that it can best serve the needs of the animal. Poorly developed skeletal systems are unable to support the heavy loads of the other body systems, and will result in an animal of lower quality and less monetary value.

B. Muscular System

1. What is the function of the muscular system, and how does it relate to quality in an animal?

This is the largest of all the body systems from the standpoint of weight. In meat-producing animals it is the most important from an

economic viewpoint. Composed of a great many separate muscles, the system is concerned with all body movements, both voluntary and involuntary, such as walking and jumping, blood circulation, digestion, respiration and excretion.

Muscles are of two types, visceral and skeletal. The visceral muscles are located in the walls of the heart, digestive system, blood vessels and other hollow organs. Skeletal muscles comprise all the flesh or lean meat of the body and represent approximately 45 percent of body weight. This edible meat is for the most part connected directly or indirectly with the skeleton. The connective tissues of the edible portions of the meat are far less tender than their lean meat contents. It follows that their presence in large quantities characterize the less tender cuts. The amount of connective tissues varies with age (greater in older animals), and within a given age animal, are more numerous in those areas where there are the greatest number of small muscles. For example, in beef there are the less tender cuts such as the shank and neck- heavily exercised parts. Since the inside muscle of the round (top round), the strip muscle of the loin and the eye muscle of the rib receive a minimum of exercise and are in themselves large muscles containing little connective tissue, they are the most tender cuts.

C. Nervous System

1. What is the function of the nervous system, and its relation to animal behavior and production?

This is the most highly developed system of a vertebrate. It is the system which enables animals to find food, fight enemies, and to guard against danger. Its function is to coordinate all activities of the body. Impulses are transmitted by nerves from the body tissues and organs to nerve centers, and in turn are sent from these centers to the tissues and organs.

This system may be conveniently divided into three main parts: (a) The central system, comprising the brain and spinal cord, which communicates with all parts of the body by means of (b) the peripheral system; and (c) the autonomic, or sympathetic system; which regulates certain involuntary functions almost independently of the central system. These three divisions have intimate relations with each other by means of connecting fibers. They are not to be considered as separate systems but as parts of the nervous system as a whole.

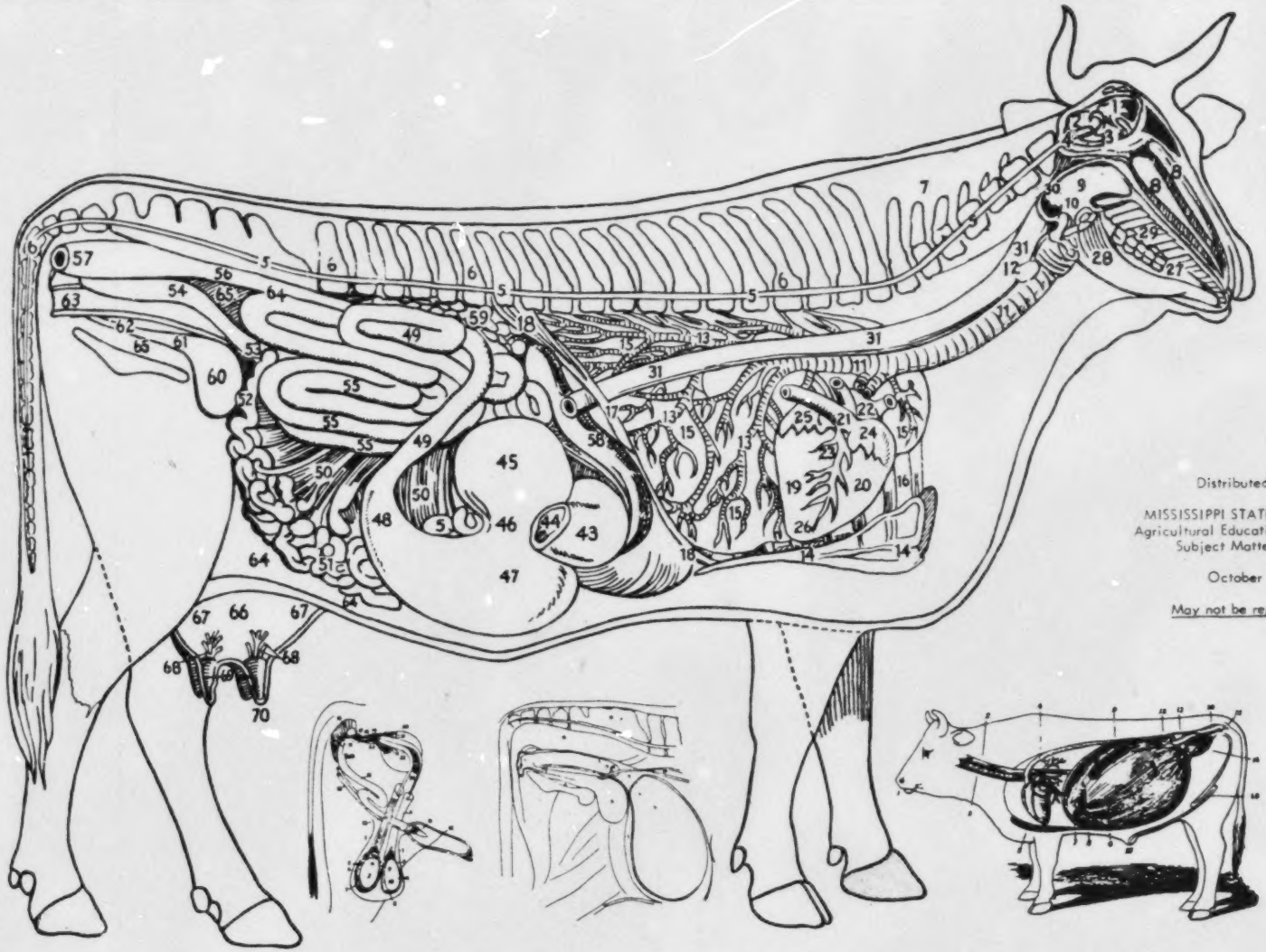
It is a well known fact that the temperament of an animal affects its behavior and production. For instance, anything which frightens the dairy cow or annoys her can interfere with the "milk let-down" process, and there may also be a decrease in the egg production of the laying flock during stress periods.

D. Circulatory System

1. What is the function of the circulatory system, and its relation to animal health, quality and value?

It consists of the heart and blood vessels which function as the transportation system of the body.

The heart is the central organ of this system, corresponding to the pump of a farm water supply station in that it pumps the blood through the vessels by strong muscular contractions, yet it differs somewhat in that the blood is eventually returned to it, afterwards



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October 1963

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Internal Organs of the Cow

1 Cerebrum
2 Cerebellum
3 Optic Lobes
4 Medulla Oblongata
5 Spinal Cord
6 Cross Section of the Vertebral Column
7 Ligamentum Nuchae
8 Terminated Rumen
9 Pharyngeal Cavity
10 Larynx
11 Trachea
12 Thyroid Gland
13 Sternum
14 Sternum
15 Right Lung
16 Pleura
17-19 Diaphragm
17 Left Ventricle
18 Right Ventricle
19 Coronary Artery
22 Aorta
23 Coronary Artery
24 Left Auricle
25 Right Auricle
26 Apex of the Heart
27 Brain Cavity
28 Tongue
29 Teeth
30 Pharynx
31 Gullet
32 First Stomach or Paunch
33 Left Sac of Rumen
34 Right Sac of Rumen
35 Pillars of Rumen
36 Villi of Rumen
37 Gullet Opening of Rumen
38-40 Divisions of Rumen
41 Spleen
42 Opening to Second Stomach
43 Second Stomach or Reticulum
44 Connection of First and Second Stomachs
45 Third Stomach or Omasum
46 Connection of Rumen With Fourth
47 Fourth Stomach or Abomasum
48 Pyloric End of Rumen
49 Duodenum
50 Mesentery
51 Jejunum
52 Ileum
53 Connection of Rumen With Caecum
54 Caecum
55 Colon
56 Rectum
57 Anus
58 Liver
59 Right Kidney
60 Bladder
61 Base of Bladder
62 Outlet of Rumen
63 Vagina
64 Body Cavity
65 Pelvic Cavity
66 Udder
67 Glandular Substance of Rumen
68 Milk Ducts
69 Milk Cisterns
70 Teat Tube

Gential and Urinary Organs of the Bull

1 Scrotum or Outer Covering of the Scrotum
2 Spermatic Cord containing the Vas Deferens the Duct through which the Seminal Fluid reaches the Ejaculatory Duct
3 Right Testicle—Outer View
4 Globus Major or Head of the Epididymis
4-5 Epididymis or the beginning of the Excretory Canal of the Testicle
7-8 Tunica Albuga or Wall of the Epididymis
9-10 Left Testicle—Inner View
11 Penis
12 Sheath or Prepuce laid open
13 Retractor Muscle of Sheath
14 Cremaster Muscle cut at Superior Extremity
15 Cut Suspensory Ligaments of Penis
16 Ischiocavernosus or Accelerator Muscle
17 Cowpers Gland
18 Part of Prostate Gland, covered by Wilson's Muscles
19 Membranous or Intrapelvic Portion of Urethral Canal covered by Wilson's Muscle
20 Ureters carrying Urine from Kidneys to the Bladder
22 Pelvic Diaphragm of the Vas Deferens
23 Testicular Ligaments
24 Duplicatures of Peritoneum

Digestive System (Left Side)

The Left Flank is Entirely Occupied by the Rumen

1 Mouth
2 Oesophagus
3 Trachea
4 Posterior Aorta
5 Heart
6 Rumen or Paunch (1st Stomach)
7 Reticulum (2nd Stomach)
8 Abomasum (4th Stomach)
9 Spleen
10 Rectum
11 Anus
12 Left Kidney
13 Left Ureter
14 Bladder
15 Ureters—in the Male
16 Sheath—in the Male

Gential and Urinary Organs of the Cow

1 Vulva
2 Urethra
3 Ovary
4 Floor of Pelvis
5 Bladder
6 Uterus
7 Outer covering of the Uterus and Inner Lining of the Abdominal Cavity
8 Os Uteri—Smaller opening leading from Vagina to Uterus
9 Peritoneum—Outer covering of Uterus
10 Ureters—coming from Kidneys to Bladder
11 Location of the Rectum
12 The Lumbar Vertebrae
13 The Spinal Canal

FIGURE 1. Body Organs of Cow and Bull.

being pumped out again into the vessels— a continuous circulating process. Blood is pumped from the heart into arteries, which are the tubes that transmit the blood from the heart to the lungs and on to the body cells. The artery branches again and again until the branches are too small in size to be seen with the naked eye. Veins, companion vessels of the arteries, conduct the blood back to the heart from the tissues.

Blood is a fluid tissue which travels through the circulatory system transporting digested food, cell wastes, oxygen, water, heat and secretions. Its function is to aid in growth and repair of cells, supply energy, regulate body processes, etc. It is composed of plasma and solid components, known as red corpuscles, white corpuscles, and platelets. Plasma contains digested food going to the body cells, and waste products on their way to the kidneys, lungs and skin. The red corpuscles carry oxygen from the lungs to the body cells. The white corpuscles, fewer in number and larger than the red, are known as "scavengers" or "soldiers" of the blood and aid in defending the body against infection. It is believed that platelets aid in the clotting of the blood.

A healthy, properly functioning circulatory system is important to the farm animal in that it has much to do with the animal's general health and quality and these in turn affect the value of the animal.

E. Respiratory System

1. What are the functions of the respiratory system, and its relation to animal health?

This is the system through which animals supply oxygen to the body cells and excrete carbon dioxide wastes.

Oxygen being fed to the body cells, in the form of air, normally enters the respiratory system through the nostrils where it comes in contact with a mucous membrane which warms, moistens and filters it. It then passes through the pharnyx (back of the throat) into the larnyx (voice box) which is commonly known as the "adams apple". It then passes into the trachea, or windpipe, the tube that connects the larnyx with the lungs. From there it enters the lungs by the way of the bronchi, two tubes at the entrance to the lungs.

Oxygen from the inhaled air is absorbed into the bloodstream which supplies it to the body cells and excess carbon dioxide is exhaled as a waste product for use by plants.

Huge quantities of oxygen are demanded by the body cells. The oxygen, as mentioned previously, must be filtered and warmed and wastes in the form of excess amounts of carbon dioxide must be excreted. An improperly functioning respiratory system will prevent these functions from being carried out and may result in an unhealthy condition.

F. Excretory System

1. What is the function of the excretory system?

This system includes the skin, kidneys, lungs, large intestine, and the liver, several of which also function as part of other systems.

Various wastes that result from body metabolism are excreted from the body by the organs of this system. The major roles played by each of the organs of this system are:

a. Skin -- The skin assists the kidneys in removing large quantities of water, "salts", and urea, in the form of perspiration. Its

most important function is that of serving as a "radiator" in regulating body temperature. In addition, to its excretory functions, the skin protects the inner tissues from drying out, and has other functions.

b. Kidneys -- They serve as blood filters, purifying the blood by removing most of the nitrogenous wastes, excess water, minerals and "salts".

c. Lungs -- In addition to their respiratory role, they excrete carbon dioxide and considerable water in the form of vapor.

d. Large intestine -- It plays a dual role as a part of both the excretory and digestive systems. Its excretory function is to excrete undigested food.

e. Liver -- The liver, also an organ of the digestive system, assists in ridding the body of waste materials by forming urea which is discharged by other excretory organs.

G. Digestive System

1. What is the function of the digestive system, and how are the systems classified?

Digestive systems are comprised of organs which prepare food for use by the body. They may be classified as follows: (a) ruminating or "cud chewing" system of cattle, sheep, and goats, and (b) the non-ruminating system of hogs, horses, and poultry.

2. How does digestion take place in ruminants?

The digestive systems of ruminants are comprised of the mouth, gullet, and the four-compartment compound stomach, which is divided as follows:

1st compartment - Rumen, or paunch
2nd compartment - Reticulum
3rd compartment - Omasum, or many-plies
4th compartment - Abomasum, or "true stomach".

Other parts of the digestive system are the small intestine and the large intestine, mouth, teeth, and esophagus.

During the eating process, these animals chew their solid food just enough to make swallowing possible. When mature animals swallow their food it passes through the gullet (esophagus) into the first compartment (rumen), which is the largest of the four compartments. The rumen contains billions of bacteria that have the ability to break down high-cellulose content feeds, thus accounting for their ability to utilize large quantities of roughage. They also have the ability to produce protein from nitrogen in the consumed feed. This synthesized protein contains all the necessary amino-acids for proper nutrition. The micro-organisms, also, produce practically all the needed vitamins.

When a ruminant has eaten enough food to satisfy its appetite, it seeks a quiet place, if possible, and proceeds to ruminate, or "chew its cud". During this process food is regurgitated, or "belched", from the rumen into the mouth where it is rechewed. (Only that portion of grain that becomes entwined in the bolus of roughage is regurgitated. Consequently, kernals of whole grain that have escaped mastication will pass through the rest of the digestion system in an unbroken condition.) After rechewing, the food is again swallowed into the rumen

where further digestive action takes place.

It then passes into the second compartment of the stomach, the reticulum, whose major function is to furnish additional storage space and to sort out and retain most foreign materials such as wire and nails.

Food then passes into the third stomach compartment, the omasum, which consists of strong muscular walls that aid in further breaking up the food material. The omasum and reticulum have common openings with the rumen from the gullet.

The food then passes into the last compartment of the stomach, the abomasum, where it mixes with gastric juice which is necessary in protein digestion.

When the food leaves the abomasum it goes into the small intestine where pancreatic, bile, and intestinal juices are mixed with it. The digestible portion is then absorbed into the bloodstream and the undigested or waste portion is passed into the large intestine and eliminated.

(Note: The rumen increases in size as the animal matures and eats increasing amounts of grain and roughage. In the case of young calves consuming milk the slit-like esophageal groove closes to prevent the milk from entering the rumen, causing it to flow directly into the third and fourth compartments of the stomach.)

3. How does the digestive process take place in non-ruminating farm animals?

The type of digestive systems of non-ruminating farm animals are less complicated than those in ruminants.

a. The digestive process in swine and horses.

The major difference in the make-up of the digestive system of these animals from that of the ruminants is that swine and horses have a simple stomach, consisting of a single compartment. The digestive process is generally the same as that of ruminants, with the exceptions that the simple stomach of these animals performs the functions of the complicated four compartment stomach in ruminants, and that regurgitative action is absent.

b. The digestive process in poultry.

This type system consists of the mouth, gullet or crop, proventriculus (glandular stomach), and the gizzard (ventriculus). It is usually classified as a simple-type system, as compared to the more complicated system in ruminants, even though it varies somewhat from the simple system of the hog and the horse.

Food taken into the mouth is mixed with saliva and forced down the throat, or gullet, into the crop, or craw, a pouch-like enlargement of the gullet, which acts as a "hopper" for the gizzard. Here the food is temporarily stored, partially softened, and some bacterial action takes place. It then passes from the crop into the proventriculus where gastric juices are mixed with it. The food remains here only a short time before it passes on into the gizzard, or muscular stomach, where it is thoroughly crushed and ground. From here on the digestive process is very similar to that in cattle, hogs, etc. However, the undigested portion of food and urine are excreted together.

(Note: Refer to Dr. Salsbury's Manual of Poultry Diseases", 1962, PP 24-25, for a diagram of the digestive system of poultry.

An excellent 16mm color film on digestion entitled, "The Rumen Story" may be obtained from the Purina Company, Checkerboard Square, St. Louis, Missouri.

H. Sense Organs and Common Integument

1. What are the functions of the sense organs and common integument?

The sense organs are the organs of the senses that receive external stimuli and conduct impulses to the brain that result in the ability of the animal to see, hear, taste, smell, and feel.

The common integument consists of the skin with its appendages of hair, hoof, feathers, etc., and serves primarily as the protective covering of the body.

I. Reproductive Systems (and Reproduction)

Perhaps no phase of physiology creates a greater interest than the study of the mystery of reproduction.

1. What is meant by reproduction?

Reproduction in animals is the process whereby new animals are produced. It begins after copulation (mating) when the sperm, the male germ cell, unites with and fertilizes the egg, or ovum, which is the female germ cell. The union of sperm and egg takes place within the body of the female, where the offspring is nourished and protected until birth.

2. What are the parts and functions of the reproductive systems of:
   a. Livestock?
      (1). The female.
      (a) Ovaries -- two glandular organs located near the posterior end of the reproductive tract. They have a two-fold purpose, in that they produce eggs, or ovum, and have an endocrine function. Each ovary contains many follicles, in which the eggs are produced.
      (b) Oviducts (Fallopian tubes) -- two funnel-like tubes leading from the ovaries to the horns of the uterus. Fertilization of the egg usually takes place near the upper end of the oviduct.
      (c) Uterus (Womb) -- a hollow organ, containing two horns, which are connected with the oviducts. Place of fetal development.
      (d) Cervix -- the neck of the uterus, that separates it from the vagina. It is known as the valve of the tubular genital tract.
      (e) Vagina (female copulatory organ) -- a passage way connecting the vulva and the cervix.
      (f) Vulva -- the reproductive and urinary organs of the female terminate here.

      (2). The male.
      (a) Testicles -- where sperm cells are produced.
      (b) Sperm ducts (vas deferens) -- two tubes connecting the testi-

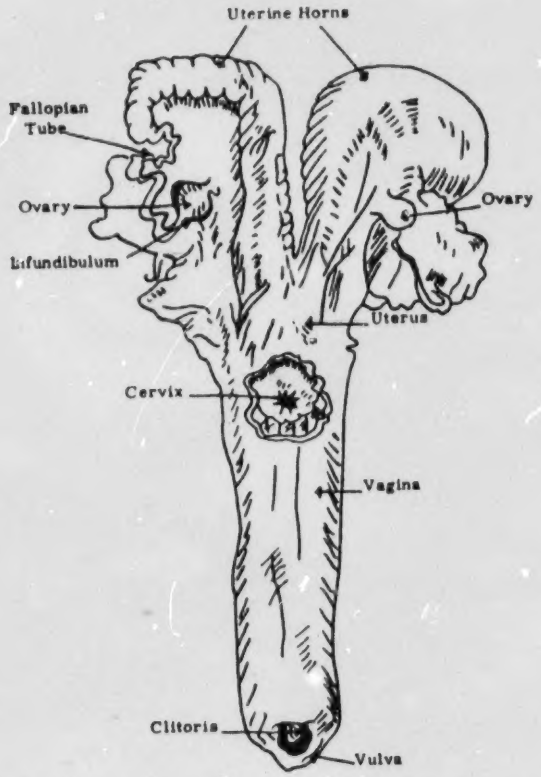


FIGURE 2. Generative and Urinary Organs of Cow.

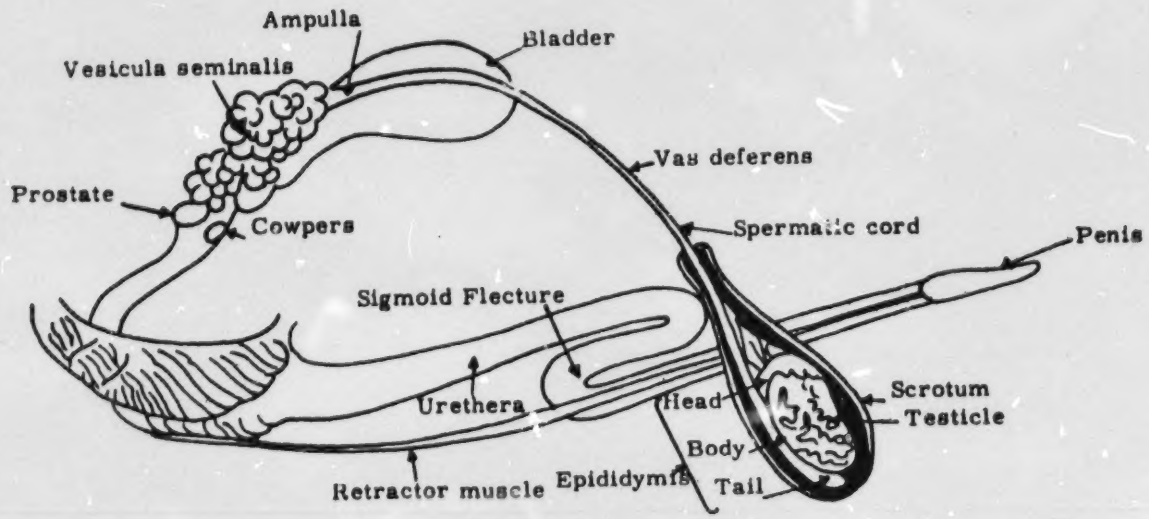


FIGURE 3. Generative and Urinary Organs of Bull.

Courtesy--

Agricultural Education Service
Auburn, Alabama

cles with the urethra. Sperms pass through these ducts and may be stored at the upper ends of these tubes.

(c) Seminal vesicles -- glands opening to the urethra. They secrete a fluid.

(d) Prostate gland -- produces a fluid that mixes with the seminal fluid. It is located near the urethra and bladder.

(e) Cowper's glands -- secretes a fluid that precedes the passage of the sperm cells down the urethra.

(f) Urethra -- a long tube that carries both semen and urine. It extends from the bladder to the end of the penis.

(g) Penis -- the organ which deposits the sperm cells within the female reproductive system.

3. How does the reproductive process take place?

Each animal has its origin when the male germ cell, or sperm, unites with the female germ cell, known as ovum or egg.

The reproductive process begins with the heat period or estrus. The estrus cycle is the chain of events dealing with reproduction, and occurring in the non-pregnant female between heat periods. During the heat period the female animal is receptive to the male. It begins by the ripening of the ovaries in the female. These eggs, when ripe, rupture the ovary walls and drop into the upper parts of the oviduct, or Fallopian tubes. They travel by gravity and motion to the uterus or womb.

During the processes of natural mating or artificial insemination the male sperm are deposited within the uterus of the female. These minute-size "wiggle-tale" sperm immediately begin to seek-out an egg. If no uniting takes place the female fails to conceive and the germ cells are absorbed by the body and the heat period is repeated. If, however, a sperm is successful in fertilizing an egg then the female conceived and a new individual begins to develop. Normally only one sperm unites with an egg.

After being fertilized, the egg soon passes down the tube into the uterus or womb. Here it finds nourishment and quickly develops by the process of cell division. The embryo becomes attached to the mucous membrane of the uterus, where it has direct contact with the functioning organ systems of the mother, remaining dependent throughout the entire gestation, or pregnancy period. Then, as soon as the development of the new individual is complete, the individual breaks contact with the body of the mother and is born.

(Note: If more than one egg becomes fertilized and develops, multiple births occur. However, twins, triplets, etc. originated in this manner are fraternally related and are no more alike than other brothers or sisters. On the other hand, when multiple births occur from the division of a single egg that has been fertilized by a single sperm, these individuals are identical. Identical individuals closely resemble each other in physical traits and mental characteristics, and are always of the same sex.

When a bull and heifer calf are born twins, the heifer is often sterile, and is known as a free-martin. This sterility is due to the hormones of the male being dominant to those of the female, which results in imperfect development of the heifers reproductive system. Most cattlemen, for instance, pre-

fer single births due to the above reason, the increased mortality rate of twins, and the tendency of the dam of twins to have a decreased conception rate.)

4. What is the reproductive cycle in domestic animals?

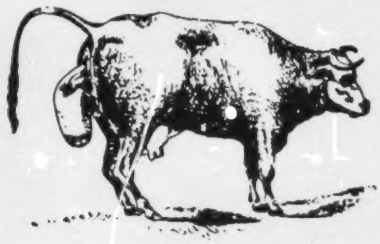
Species	Age of Puberty 1/	Breeding Season	Duration of Cycles (days)		Duration of Heat Period		Time of Ovulation 2/	Duration of Gestation 3/ Period (days)
			Average	Variation	Average	Variation	(In relation to heat period)	Average
Cow	4-8 mos.	All year	21	18-24	14 hrs.	8-30 hrs.	14 hours after end.	281
Sow	3-5 mos.	All year	21	18-24	2-3 days	1-5 days	Toward end	113
Ewe	First fall 4/	Fall 5/	16½	14-20	35 hrs.	1-3 days	At end	150
Goat	First fall	Fall	Approx. 21	15-24	2½ days	2-3 days	Toward end	151
Mare	1 year	Spring 6/	22	16-30	6 days	2-11 days	1-2 days before end	336
*Cat	Very variable	Seasonally - 2 or more per year	-	15-21	4 days	-	Induced 26-27 hrs. after mating	64
*Dog	Very variable	Fall and spring	-	-	9 days	4-13	Near beginning of heat period	60

1/ Age when animal becomes of breeding age. Varies with breeds and individuals.
2/ Period when egg is released from the ovary and is capable of being fertilized.
3/ Period of pregnancy. Varies with breeds, individual, etc.
4/ If unbred during this period, season extends to late December or early January.
5/ Dorset Horn and Merino breeds may breed any time of the year.
6/ If unbred may continue heat periods for a variable period.

* Even though these species of animals are not of economic importance on the farm this information is included here, due to the many request for such information.

FIGURE 4. Obstetrical Chart - Cow.

A. Foetal Membranes of the Cow at Mid-Term--Uterus Open on its Left Side.



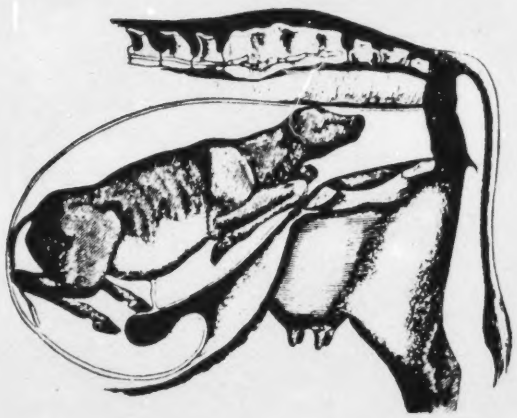
B. Beginning of Act of Parturition.

C. Foeti No's 1 & 2 --Normal Position, Twin Pregnancy.

Foetus No. 2 --Normal Position, Single Pregnancy.

D. Anterior Presentation: Lateral Deviation of the Head Towards the Abdomen (Abnormal Position).

E. Posterior Position of the Foetus (Abnormal Position).



F. Fore-Limbs Flexed at the Knees, in the Anterior Presentation. (Abnormal)

b. Poultry?

The reproductive process of the young in poultry differs considerably from that in livestock.

During the formative process of the egg within the reproductive tract of the hen the germ-cell deposited by the male fertilizes the female germ cell, which is located on the outer edge of the yolk of the egg. This marks the beginning of a new chick. If after the egg is laid proper temperature is maintained the embryo continues to develop. Proper humidity is also necessary for successful development. During the development period the embryo receives its nourishment from the egg contents, which are completely consumed at the end of the twenty-one day hatching period.

(Note: It is not necessary for the male to deposit sperm within the reproductive tract of the female between the laying of each egg since the sperm retains its full fertility for approximately six days. The fertilizing ability of the sperm decreases thereafter to approximately fifty percent on the tenth day, and to approximately fifteen percent on the 19th day. Occassionally eggs may be fertilized up to twenty-six days after a single insemination.)

Days	Chick Development in an Egg During Incubation
1 - 3	Development is continued during the incubation period after the egg has been laid.
4	A network of bloodcells are visible.
7	The head, limbs, eyes and abdomen are evident.
8	The legs and wings are well-formed. Toes are noticeable.
9	Down appears on parts of the body. Beak is fairly well-formed.
19	Embryo is well-covered with down. Yolk sack is being drawn into the abdomen as the last of the food is utilized.
21	The embryonic development is complete and the chick frees itself from the egg shell.

5. What effect does pregnancy have on lactation?

The period of lactation in milk producing females is the period of secreting and yielding milk by the mannary glands. In dairy cows, the yield of milk after calving usually increases for a period of time and then gradually decreases as lactation advances. Pregnancy has no appreciable effect on the milk yield until after about 5 months, after which it hastens the decline.

6. What is the relation of an animal's reproductive capacity to profit?

Fertility and sterility are two terms that relate to the reproductive capacity of an animal. Fertility refers to the ability of the male or female to produce viable germ cells that are capable of uniting with

the germ cells of the opposite sex and of producing vigorous, living offspring. Fertility is lacking in very young animals. It first manifests itself at puberty, increases for a time, levels out, and then decreases in very old animals.

Sterility, on the other hand, means exactly the opposite of fertility-infertility or barrenness. It may be defined as the inability of an animal to reproduce, and may be temporary or permanent. The incidence of sterility varies considerably from herd to herd, and from year to year within the same herd. Fortunately, very few barren cows or sterile bulls are permanently and totally infertile. It is believed by authorities that approximately 10% of the infertile or sterile cases are due to inherent traits while the remainder are due to environmental conditions such as genital infections, diseases, silent heat periods, failure to come into heat, excessive inbreeding, poor feeding practices, poor management, etc.

The possibility for profit in a given livestock enterprise is practically dependent upon the breeding efficiency of the animals within the herd. In fact most beef cattlemen, acknowledge that the calf crop percentage is the largest single factor affecting profit in beef cattle production.

7. What are the methods of breeding animals?

Two methods are commonly practiced: (a) natural breeding - controlled and uncontrolled, and (b) artificial breeding.

a. Natural breeding -- Controlled natural breeding, one of the two natural types, consists of confining the male and bringing the female to him. This manner is very commonly used by purebred breeders because registration requires specific breeding information that would not be obtainable under the uncontrolled method. Uncontrolled natural breeding, or pasture breeding, is simply allowing the male animal to run with the females in the pasture.

b. Artificial breeding -- This method consists of a practice in which semen (spermatazoa) is collected from the male artificially and inserted into the reproductive tract of the female. This method of mating farm animals is very common with dairy cattle, but to a lesser degree with other animals.

8. What are the different systems of animal breeding?

A breeding system is a system of mating animals in order to produce a given result. Successful breeders follow a breeding system, the purpose of which is to give greater control of heredity than if selection alone is used. Therefore, breeders need to know about the different breeding systems. The various systems of breeding are (a) inbreeding, (b) linebreeding, (c) outcrossing, (d) crossbreeding, and (e) upgrading. These systems may be practiced with either grades or purebreds. There is no one best system. Each has its advantages and disadvantages depending upon the situation of individual livestock-men. In determining the system of breeding to use, careful consideration should be given to such factors as the size and quality of the herd, skill and experience of the farmer, operating capital, and the purpose of the production program.

a. Inbreeding -- This system of breeding involves the mating of closely related animals such as sire to daughter, brother to sister, or son to mother. This system if often referred to as closebreeding. It was widely used in foundation stock in the establishment of practically all

of the beef breeds in order to intensify the production of animals uniform in type and other characteristics. The use of this system is now limited to a comparatively few breeders who have purebred herds of such highly developed type and quality they feel that no further improvement could be made by getting breeding stock outside their own herds.

Just as inbreeding intensifies desirable traits, by the same token, it intensifies undesirable characteristics or weaknesses. Therein lies the danger of inbreeding for all livestockmen with herds of no more than average quality. The use of this system requires very rigid culling to eliminate the "fixing" of undesirable traits, and hence is rather expensive.

b. Linebreeding -- Actually, this is almost the same system as inbreeding, just less intense. It consists of mating animals not closely related such as half brother to half sister, cousins, grandparents to their offspring, etc., all of which trace in pedigree to an outstanding ancestor. This system of breeding was widely used in developing family lines or bloodlines that have been so popular during recent years.

This system of breeding does not offer the possibilities for improvement as does inbreeding, nor does it offer the possibilities for regression or the intensifying of undesirable characteristics as inbreeding does. It is more nearly adapted for improvement in the herds of larger purebred operations. It is never used in grade or commercial herds.

c. Outcrossing -- This system of breeding consists of the mating of animals of the same breed which have no close-up relationship in the pedigree. For practical purposes they might be considered as unrelated animals. This system is probably the most widely used among the purebred breeders, except in the largest and most highly advertised herds. Outcrossing is sometimes referred to as linecrossing and is a very practical and relatively safe breeding program because it is very unlikely that two unrelated breeding animals would transmit the same undesirable traits to their offspring. In fact, many purebred breeders often remedy a weakness or undesirable trait that occurs in their herd by outcrossing with an animal known to be especially strong in such trait.

d. Crossbreeding -- This system consists of the mating of purebred animals of different breeds. It is the system of breeding that has been used to develop many comparatively new American breeds of livestock.

In broad terms, crossbreeding also includes the mating of purebred sires of one breed with high grade animals of a different breed. This is the practical application of crossbreeding made by most commercial livestock-men with grade herds. Crossbreeding gives the offspring the advantage of hybrid vigor, and often an increase in rate of growth and efficiency of production. When a good selection is made of breeding animals, particularly the males, used in crossbreeding, the desirable traits in both parents seem to be strengthened and the undesirable traits seem to become recessive or overshadowed. The limitation of this system of course lies in the female replacement program, for in a very few generations one most likely would have a herd lacking uniformity size, color, and conformation if he attempted to save replacement females from his own herd.

e. Upgrading -- This is the system of breeding where purebred males of any pure breed are mated to native, nondescript grade females. The purposes are to develop uniformity, improve quality, and increase performance in the offspring. Naturally, the greatest progress is made in the first cross because 50 percent of the inheritance of the offspring comes from the sire. Progress will continue to be made by following this system. By the fourth generation cross, the animals will be carrying about 94 percent pure blood.

This is the breeding system followed by nearly all commercial beef cattle producers in Mississippi and wonderful progress has been made during the past decade or more in improving the quality of our cattle. The big problem is getting farmers to select really good purebred bulls to use in this system.

(Note: Purebreeding is not a system of breeding as is often believed. The production of purebreds is a system of production or type of operation. For example, within beef cattle farming several of the types of operations, or systems of production, are (a) purebred, (b) baby beef, (c) cow and calf, (d) stocker, and (e) fattening.

The words "purebred" and "thoroughbred" are not synonomous and should not be confused. A purebred animal may be defined as a member of a breed, the animals of which possess a common ancestry and distinctive characteristics; also, he is registered or eligible for registry in the herd book of that breed. Thoroughbred is a breed of horses.)

9. What is meant by a "breed of livestock"?

A breed may be defined as a group of animals having a common origin, and possessing certain well-fixed and distinctive inherent characteristics not common to other members of the same species. For example, there is the Hereford beef cattle breed, the Jersey dairy cattle breed, and the Poland China breed of hogs.

10. What is meant by bloodline, or "strain"?

The term bloodline, or "strain", as used here might be considered to be synonymous with families or family lines of breeding. In the development of various breeds within the various species of animals, individuals often use unrelated animals in their breeding program; thus separate families, or bloodlines (sometimes called "strains"), soon take on significance of certain characteristics of the breeds. These breeders have done this in an effort to improve certain characteristics within their breed.

11. What is meant by "typiness" in livestock?

Typiness in animals may be defined as an ideal combining all the characters that contribute to the animals usefulness for a given purpose.

There are several distinct types of animal within each species of livestock. Within the cattle species there are the following types:

a. Beef type -- These are animals fed for the purpose of converting feed into maximum meat. Examples are the Hereford, and Aberdeen-Angus breeds.

b. Dairy type -- In contrast to the beef-type, these animals are bred in such a way that their major purpose is the production of milk. Examples are, Jersey, Guernsey, and the Holstein-Friesian breeds.

c. Dual-purpose type -- Animals of this type are combination meat-milk producing animals that are intermediate between the beef and dairy types. Examples are, the Milking Shorthorns and the Red Poll breeds.

In addition, there is another known as the Draft-type. Even though

very few of their type exist in this country, they are an important source of power in some parts of the world. They are characterized by their ruggedness, vast size and length of leg.

Within the swine species there was for years the (1) Lard-type, and (2) Bacon-type of hogs. The demands of the consumer have long since changed and is today for a meat-type hog. Today, an animal of this type is neither lard or bacon-type, nor a cross between these types. The meat-type hog is characterized by its ability to yield a high percentage of high quality lean meat. The ability of this type hog to do just that is due to the fact that it is a bred-in characteristic, and not the result of reduced amounts of feed. There is no one breed of meat-type hogs, but rather there are meat-type hogs within many different breeds. Some of the more recently developed breeds have been developed specifically toward producing only meat-type hogs, and many breeders of long established hog breeds have made much progress along this line.

Within the poultry species the types are classified as (1) Egg, and (2) Meat types.

12. How does type, breed, and blocdline (family line or "strain") affect quality and value of farm animals?

As implied in the above question, type, breed, and bloodline influence the quality and value of an animal.

Type, as previously discussed, refers to the various types of animals within the several species of livestock and poultry -- beef, dairy, and dual-purpose types among cattle, and the various types among other species. "Typiness", also previously discussed, refers to the ideal type combining all the characteristics that contribute to the animals usefulness for a given purpose -- beef type for beef, dairy-type for milk, etc.

When the housewife goes to market she is usually looking for, and willing to pay for, good meat. To meet this demand it is, of course, necessary for the producer to grow the type of meat that meets her requirements. If she is looking for good beef, then she will more likely get it from carcasses of beef-type cattle rather than from those of dairy-type or beef-dairy crosses, because dairy and beef-dairy crosses do not have the conformation and quality, and generally do not have the finish, afforded by beef-type animals. If she is looking for good pork, she will be more likely to find it in carcasses produced by meat-type hogs, which produce a high proportion of lean to fat. Likewise, she will find that the best broilers come from the broiler-type strains rather than from those of the egg type. When the milk producer goes to market to buy an addition to his dairy herd he is looking for a true dairy-type animal because it will produce him more milk and do so more profitably than an animal of beef or dairy-beef cross. Consequently, type does affect the quality and value of an animal.

It is sometimes believed that there is very little difference between the quality and value of breeds, but a great deal of difference between individual animals within a breed. It is true that a great deal of difference exists among individuals. And it is usually true that not a great deal of difference exists between some breeds, but this does not necessarily hold true for all breeds. Actually there are differences between the breeds of the various species of animals, differences between the various bloodlines (family lines or "strains") within each breed, and differences between individuals themselves within these bloodlines.

(Note: Many factors should be considered when selecting breeds, bloodlines and individuals; however, since the intent of this publication is to furnish information dealing with certain basic principles, these factors are not being listed here but are to be listed and considered when the student is actually in the process of selecting a breed, bloodline and an individual animal.)

The following are merely a few pointers to show that differences exist between breeds, between bloodlines within a breed, and between individuals within a bloodline:

a. Dwarfism in cattle, while probably appearing in all breeds, appears more often within some breeds than others, and within these breeds it appears more often in some bloodlines than in others.
b. Within a given specie of meat animals there is little difference in the dressing percentage of most breeds. Yet, several breeds within each specie tend to yield a higher dressing percentage than others, and tend to produce a higher grade of meat in a shorter period of time. Likewise, there is a variation between the dressing percent of animals from the different bloodlines, as well as between individual animals within these bloodlines.
c. Calves of some breeds consistently outgain calves of other breeds when they are marketed as milk-fed calves. There are also variations among the bloodlines, and between individuals within these bloodlines.
d. Some breeds of beef cattle are often harder to handle as live animals — thus influencing in an indirect manner their market value.
e. Animals of some breeds of beef cattle are more susceptible to pinkeye, and to cancer eye than are animals of the other breeds.
f. Breeds of dairy cattle vary in their milk-producing characteristics.
g. Breeds, varieties and strains of poultry vary in their ability to produce eggs and meat. Some breeds, for instance, produce white eggs, while others produce brown eggs. These colors in some instances affect the salability of the eggs on the market.

Even though some breeds vary in their abilities, keep in mind that different strains within each of these breeds often vary considerably and that within each strain of each breed there are often considerable differences among individuals.

II. Nutrition of Farm Animals

1. How are feeds utilized by animals?

Approximately one-half of the nutritive content of feeds are used merely to maintain the necessary life processes, such as providing energy for body movements, food digestion, maintaining and regulating body temperature, etc. The remaining nutrients provide for growth, fattening, and reproduction.

2. How are the following terms defined?

a. Nutrient -- This term is applied to any food constituent, or group of foods of the same general composition, that nourishes and promotes growth. Proteins, carbohydrates, fats, minerals, and vitamins are the classes of nutrients. Although not actually a nutrient, water is usually listed with them because it is essential for most body functions, including the digestion of food.

b. Digestible nutrient -- This term, usually applying only to protein, carbohydrates, and fats, means that portion of a nutrient which may be digested and utilized by the body.

c. Ration -- A ration is the total feed allowed for a given animal during a twenty-four hour period.

d. Balanced ration -- This is one which furnishes over the twenty-four hour period all of the feed nutrients in the necessary proportion and amounts to provide proper nourishment.

3. What is the relationship of nutrients in feed to the animal's body functions?

a. Proteins -- are necessary for growth, reproduction, and maintenance. They build muscles and new tissues (including lean meat), and repair worn-out or damaged tissue. Protein not needed as protein may be used to supply energy. They are very essential in the production of animal products such as meat, milk, eggs, and wool. Protein constitutes the greater part of muscles (including lean meat), internal organs, cartilage and connective tissues, skin, hair, horns, and hoofs. Some of the feeds high in protein content are cottonseed meal, soybean oil meal, tankage, skim milk, leguminous hays, etc.

b. Carbohydrates -- furnishes energy required for body functions. Excessive amounts above maintenance requirements are stored throughout the body in the form of fat. They are the chief sources of body fat, and are found in large quantities in corn, oats, hay, cottonseed meal, cottonseed hulls, soybean oil meal, etc.

c. Fats -- perform practically the same function as carbohydrates, but are a concentrated source of energy providing pound for pound $2\frac{1}{4}$ times as much energy as carbohydrates. Examples of feeds high in fat content are meatscraps, tankage, and cottonseed. (Whole cottonseed contain approximately 3 times as much fat as cottonseed meal. This is due to most of the fat being extracted during the meal-manufacturing process.)

d. Minerals -- give strength to the bone, helps manufacture red pigment in blood, and are essential in all body processes. Feeds, especially legumes, grown on well-mineralized land are usually higher in mineral content than are feeds grown on land that has not been well-mineralized. The

major mineral needs of the animal are usually supplied in the form of steam bone meal and common table salt, plus ground limestone in some instances. Minor elements usually are provided in ample quantities in the feed; however, deficiency systems resulting from a shortage of these minor elements may show up, necessitating the providing of them.

e. Vitamins -- regulate body functions, helps keep the body in a healthy condition, and aids in developing resistance to infections and diseases. Most of the animal's body needs of vitamins are provided by feeds such as silage, well-cured hay (especially legumes), well fertilized pasture plants, and by sunshine.

Synthetic vitamin pre-mixes are available as a commercial mix. These pre-mixes will supply all the vitamins needed at a sufficient level to fortify the ration being fed. Commercially-mixed rations supply the necessary vitamins, also.

f. Water -- softens feed, aids in digestion, assimilation of nutrients, helps regulate body temperature, and is essential in the elimination of body wastes.

4. What value to the livestock producer is there in knowing the nutritive content of animal bodies and products?

Feeds represent by far the greatest cost item in animal production. Because of this and other reasons, it is important that the livestock producer have a basic understanding of the nutritive requirements of animals.

Knowing the nutritive content of an animal's body and animal products will be helpful to the producer in determining the kind and quantity of the various nutrients needed by animals of various species during their various stages in life.

The composition of an animal's body varies considerably, depending on their age, degree of fatness, etc. By studying the contents of the following table a producer can readily understand why some species require higher protein content feeds than are required by others, why young growing animals need rations of higher protein content than older, mature animals, and why other nutritive needs vary.

Approximate Nutritive Content -- Animal Bodies and Products

Animal bodies* and Products	Protein	Fat	Carbohydrates	Mineral Matter	Water
	Percentage				
Dairy calf, at birth	19	3	**	4	74
Dairy cow, 4 yrs. old	18	18	**	5	59
Beef calf, 100 lbs. net	20	4	**	4	72
Steer (med. fat) 1,200 lbs. net	16	32	**	4	48
Young chicken 1/2 lb. net	21	4	**	4	71

Older chicken 4 lbs. net	20	20	**	4	56
Pig, 100 lbs. net	15	16	**	3	67
Hog (med. fat) 200 lbs. net	14	29	**	3	54
Fluid Whole Milk	3.5	4	5	1.7	85.8
Egg (Including shell)	11.8	11	**	11.7	65.5

* Not including contents of digestive system.
** Usually less than 1%. To get total energy producing values and needs, multiply precent fat by 2.25. Add this to percent carbohydrates if given.

5. Why is the quality of protein important in feeding swine and poultry?

Protein is a very complex nutrient made up of at least 24 amino acids. Yet, 10 of these amino acids, known as the essential ones, cannot be manufactured in the digestive systems of simple stomach animals at a sufficient rate to meet their body needs. Protein having the proper proportions of all the essential amino acids is said to be protein of high quality, while protein furnished by feeds or rations in insufficient amounts of these essential amino acids is said to be protein of low quality. Many common feeds contain inadequate amounts of one or more of the essential amino acids. For example, all the grains are low in one or more of these amino acids -- corn is deficient in two of them. It is fortunate, however, that all of these are not deficient in the same ones. In general, animal source feeds such as meat scraps, skim milk, etc., are high in protein quality. Consequently, whenever necessary, the proper combination of these feeds can be made to provide all the essential amino acids.

Low quality protein presents no problem in rations of ruminants and horses, since their digestive systems are capable of taking even low quality protein or urea and manufacturing sufficient amounts of the essential amino acids from it. This means simply that it is not necessary that rations of these animals contain feeds high in protein quality. It does not imply, however, that the amount of protein needed by the animal is not important.

On the other hand, the quality of protein may be just as important as the quantity of protein in swine and poultry rations. The simple stomachs of these animals are unable to produce all of the essential amino acids in sufficient amounts from feeds low in protein quality. The high quality protein must be provided in their rations, or they will fail to properly utilize the other feed nutrients.

6. How are feedstuffs classified?

Feedstuffs making up a ration are generally classified according to their fiber content or bulk— as concentrates, and roughages. Some authorities list succulent feeds (silage, green pasture grasses, etc.) as another class of feedstuff. However, since plants classifying as succulent feeds are feeds that are usually high in fiber, they are classed herein as roughages.

Concentrates are feeds that are high in total digestible nutrients (T.D.N.) and low in fiber. (Fiber is cellulose materials in feedstuffs that are hard to digest.) All the common feed grains, which are low in protein content, are classified as concentrates. Concentrates are added to the roughages fed ruminants and horses in order to increase the nutritional value of the ration to the desired level. Concentrates form the greater part of the ration for poultry (approximately 97%) and swine (approximately 94%).

Roughages include hay, pasture, and silage materials. These plants are high in fiber content, and usually low in T.D.N. Beef cattle and other ruminants, as well as horses, are efficient utilizers of good roughages. Because of this fact and the fact that roughages yield more nutrients per acre than grain crops, roughages are the basic part of the rations of these animals.

7. What are the characteristics of concentrates?

a. Grains (corn, oats, wheat, barley, grain sorghums, and rye.)

(1) General characteristics.

(a) Grains:

-- are nutritionally unbalanced for any kind of livestock. (A good rule of thumb– never feed grain alone.) They are low in protein quality, also. To correct this deficiency provide leguminous plants or protein supplements as part of the ration.

-- are high in T.D.N. content– since it is a concentrate feed.

-- vary in mineral content, but are all low in calcium– especially corn. Most are high in phosphorous– even higher than common grasses and legumes.

-- are palatable in most instances. Corn is probably the most palatable– rye the least.

-- are not usually considered good sources of vitamins; however, yellow corn is a fair source of vitamin A activity. (By "vitamin A activity" we mean that vitamin A is not contained in feeds in the form of a vitamin, but in the form of carotene, which is converted into vitamin A.) Yet, these deficiencies may be corrected by providing good quality legume hay or pasture. A well-balanced ration and sunlight will supply adequate vitamins. (Sunlight does not supply vitamin D but it converts a compound which exists in the skin into vitamin D.)

-- are used as a supplement to pasture plants and roughages, which are high in fiber and low in T.D.N. and compose the bulk of the feed for beef and dairy cattle, and sheep. Cattle and sheep are ruminants and are equipped with a digestive system that can handle large quantities of roughage. Consequently, they do not need large quantities of concentrates. On the other hand, swine and poultry digestive systems are unable to handle large quantities of roughage, so they need a greater portion of concentrates in their rations. Most rations should vary in protein content from 12 to 20 percent, depending upon the purpose for which fed, age, etc. This usually necessitates the use of a protein supplement in a ration, since roughages range in protein content from 2 to 12 percent.

(2) Specific characteristics.

(a) Corn:
- -- is the basic feed for livestock, ranking ahead of other cereal grains in importance for livestock feeding.
- -- is usually cheaper per pound of T.D.N. than other grains.
- -- is very palatable to all livestock.
- -- is low in protein, but high in carbohydrates. Yellow corn is high in vitamin A activity.
- -- is a good grain for fattening purposes.
- -- may be fed whole to swine, poultry, and horses; but it should be ground for dairy cattle and cracked for young chicken

(b) Oats:
- -- are approximately 80 to 85% as efficient as corn (pound for pound).
- -- are good for young animals and breeding stock since they are high in bulk and minerals.
- -- are important in "fitting" content.
- -- are low in vitamin content.
- -- should be crimped or ground for dairy, beef, and swine, but do not have to be for sheep or calves less than one year old.

(c) Wheat:
- -- has approximately the same feeding value as corn.
- -- is very palatable.
- -- is usually too expensive to feed.
- -- cannot be fed in large quantities due to chances of digestional disturbances occurring.

(d) Barley:
- -- has approximately 90% of the feeding value of corn.
- -- may bloat cattle when fed in large amounts.
- -- is good in a mixture of feeding rations.
- -- should be ground for all livestock except sheep.

(e) Grain sorghums:
- -- are approximately 90 to 95% as efficient as corn. They are slightly higher than corn in protein, but lower in fat.
- -- should be ground for dairy, beef, and poultry mashes. However, it is not necessary to grind them for swine, sheep, and horses, and for poultry scratch feed.

(f) Rye:
- -- has about the same feeding value as corn.
- -- is unpalatable to all animals - they will not eat much of it. It should compose only 20 to 30% of a ration.
- -- may cause digestive disturbances when fed in large amounts.
- -- should not be fed until it has passed through a sweat or is conditioned when stored after threshing.
- -- should be coarsely ground or rolled for feeding all livestock and poultry.

NUTRITIVE VALUE OF GRAINS

GRAIN	DIGESTIVE PROTEIN (D. P.)	TOTAL DIGESTIBLE NUTRIENTS	TOTAL DRY MATTER	FIBER
	Percentages			
Corn	6.9	82.5	88.2	2.4
Oats	9.0	68.5	89.8	12.1
Wheat	11.1	80.0	89.5	2.6
Barley	9.2	75.6	89.3	6.2
Grain Sorghum	8.4	79.9	89.6	2.3
Rye	10.0	76.5	89.5	2.4

b. Protein Supplements.

Protein supplements are high in T.D.N. and especially high in protein, with the exception of urea, which contains no energy producing nutrients. Supplements are classified into three categories according to their source:

Source	Examples
Plant	Cottonseed, soybean, linseed, and peanut oil meals; alfalfa leaf meal, corn gluten meal, brewer's dried grains, etc.
Animal	Meat scraps, tankage, skim milk, fish meal, blood meal, etc.
Synthetic	Urea

Cattle, sheep, and horses do well on supplements from plant sources. Swine and poultry do better on rations that contain some protein from animal sources as well as some from plant sources, due to the higher quality protein of the supplements from animal sources. However, one exception to this rule is soybean oil meal which has proven satisfactory as the only protein supplement in hog rations.

(1) Animal Sources.

(a) Meat scraps and tankage:
-- are primarily used as protein supplements in swine and poultry rations.
-- generally range in protein from 40 to 60 percent.
-- correct the grain protein deficiencies, but are less effective

single supplements to the grain than are soybean meal or fish meal.
-- may be used in poultry rations, but meat scraps and bone meal are preferred.

(b) Blood meal (dried blood):
-- is made from blood meal collected at the packing plant.
-- is used primarily in rations for young calves, poultry, and occasionally young pigs.
-- is usually low in digestibility, palatability, calcium, and phosphorous, and the protein content is lower than that of meat scraps and tankage.

(c) Fish meal:
-- is made chiefly from the wastes of fish.
-- is high in protein- approximately 60 percent.
-- usually is not palatable other than to swine and poultry, and therefore is not recommended in rations other than these.

(d) Skim milk:
-- is slightly higher in protein, milk sugar, and minerals than whole milk, due to the removal of most of the fat.
-- is low in vitamin A activity (carotene).
-- is fed chiefly to pigs, poultry, and dairy calves.
-- one gallon replaces one pound of linseed oil meal.

(2) Plant Sources.

(a) Cottonseed meal:
-- has protein of high quality- good for correcting protein deficiency of cereal grains for cattle and sheep.
-- is high in T.D.N.- approximately 74 percent.
-- is high in phosphorous.
-- should be fed lightly to swine and poultry, due to possible danger from gossypol poisoning when fed in large amounts.

(b) Soybean oil meal:
-- is one of the best protein supplements for all animals, especially if its cost is favorable.
-- is a high quality supplement, ranking ahead of other plant protein supplements in swine and poultry rations.
-- is lower in calcium and phosphorous than cottonseed meal or linseed oil meal.

(c) Linseed oil meal:
-- is a by-product of flaxseed.
-- is a very popular protein supplement.
-- is high in protein and palatability.
-- is slightly laxative in effect.
-- is excellent as the only protein supplement for cattle, sheep, and horses.
-- should be mixed with animal source proteins if fed to swine and poultry.
-- gives a sheen to animals hair, which is valuable to show animals.

(d) Peanut oil meal:
-- is a good protein supplement for livestock, but should be mixed with other protein supplements when fed to simple stomach animals, because its protein is only fair in quality.
-- is very palatable.
-- is low in calcium and phosphorous.
-- is high in T.D.N.

(e) Alfalfa leaf meal:
-- is low in fiber, and high in vitamin A activity.
-- contains approximately 20 percent protein.
-- is very good in poultry rations.

(f) Corn gluten meal:
-- is a by-product of the manufacture of corn starch and sugar.
-- is high in protein content- averages approximately 43 percent.
-- is mainly used in dairy rations and should be fed in combination with other protein supplements.

(g) Brewer's grain:
-- is a by-product of barley used in the beer-making process.
-- is not very palatable, but may be made tastier by mixing it with more palatable feeds.
-- is fed chiefly to dairy cattle, but may be fed as part of the concentrate mixture in beef and sheep rations.

(3) Synthetic Sources.

In addition to protein supplements being available from animal and plant sources, a synthetic source is also available. Protein substitutes in the form of simple nitrogenous compounds are available. Urea is the form that has proven most successful.

Urea is the chief nitrogenous waste product in the urine of most animals, and is now manufactured synthetically on a large scale from the nitrogen in the air. Our supply of protein supplements from animal and plant sources is insufficient to balance properly the rations of our fast growing animal population. Thus, urea is filling a great need.

Urea is suitable only as a replacement of a portion of the protein requirements of ruminating animals. It cannot replace all of the protein supplement, and is not suitable as a supplement for non-ruminants, or dairy calves whose rumen is not well-developed. The principle involved here is that bacteria in the rumen, the first compartment in the compound stomach of ruminants, convert the nitrogenous urea into protein that can be utilized by the body. Non-ruminants, or dairy calves with little developed rumens, are unable to make the conversion.

When feeding urea, the animal's ration must contain sufficient energy-producing nutrients for the bacteria to efficiently convert the urea into protein. Since urea provides only protein, sufficient energy must be provided from the other feed materials to furnish the bacteria with the necessary amount of energy. The conversion of urea into protein is also inefficient when it is added (1) to a mixture that is already fairly high in protein, (2) to hay alone, without any concentrates, (3) to molasses and such roughage as grass hay. However, it can be converted into protein effectively when the concentrate mixture contains a good supply of grain, along with some molasses.

Too much urea in a concentrate mixture may render it unpalatable, and excessive amounts may poison animals.

8. What are the characteristics of roughages?

Good quality stored roughage is second in line as a low cost livestock feed- pasture is first, silage is third, and concentrates are the highest. One of the greatest needs in a good feed program for ruminants are adequate amounts of high quality hay and silage. More high quality legume hay and corn silage are highly needed- especially in dairy feed programs. A good roughage program can be built around high-yielding perennial crops.

There may be considerable variations in the feeding value of any specific kind of roughage. Pasture plants grown on well-fertilized land are more nutritious and palatable than pasture plants growing on unfertilized or poorly fertilized soils. Plant maturity and the method of harvesting and curing also affect the nutritive value and palatability of plants.

(a) Hay (legumes):
- -- leads in yield of palatable hay per acre.
- -- contains more protein than any of the common forages.
- -- vitamins - excels in A; is high in D and riboflavin and other B complex vitamins.
- -- minerals - highest in calcium of all the homegrown fields; relatively low in phosphorous.
- -- T.D.N. content approximately 50%; fiber content usually 25-30%.

(b) Hay (grasses):
- -- lower in protein, calcium and vitamins than legume hay.
- -- usually less palatable than legume hay.
- -- quality affected more by cutting stage than legumes.
- -- requires more protein supplement to balance a ration than does legume hay or grass-legume mixtures.

(c) Silage:
- -- is highly palatable, thus it increases feed consumption.
- -- is slightly laxative.
- -- from corn usually provides 1/3 more T.D.N. per acre than alfalfa hay and up to twice as much as some grass hays.
- -- from corn is worth 30 to 40% as much as good hay for dairy cows, and 50% as much as good hay for beef cattle.

(d) Cottonseed hulls:
- -- are low in T.D.N. - 43.7%, or approximately the same amount as furnished by oatstraw.
- -- contain no digestible protein.
- -- are low in calcium, very low in phosphorous, and lacking in vitamin A activity (carotene).
- -- when properly fed are worth more per ton than corn stover, straw, or poor hay.
- -- are a good source of energy when price is favorable.

(e) Corn stover, straw, etc.:
- -- is high in fiber, extremely low in proteins and T.D.N.
- -- is low in calcium and phosphorous.
- -- is low in vitamins except for straw which has considerable vitamin D activity.

9. What are the characteristics of a good ration for animals?

A satisfactory ration for animals, in addition to supplying the required nutrients, must be made up of feeds that will give it the following desirable characteristics:

(a) Palatability -- A good ration must be palatable, or "tasty"; in other words, the animal must like it. Like man, these animals differ in the feeds they like and those they dislike. In general, the animals tend to like the feeds they are used to; therefore, if changes in the ration are to be made, these changes should be gradual. Some of the more palatable feeds are pasture plants (especially young ones), high quality hay, corn silage, corn, oats, wheat bran, molasses, and cotton seed meal.

(b) Protein quality -- An important consideration in feeds for swine and poultry. (Refer to Unit II - Nutrition of Farm Animals, question 5 on page 25 for additional information.)

(c) Variety -- while important in the rations of all animals, is more important in the rations for simple-stomach animals, particularly hogs and poultry. However, other factors such as cost being equal, a variety of feed is desirable. Variety improves palatability, enabling the animals to eat more. It also provides a greater variety of nutrients, especially vitamins and minerals.

(d) Bulkiness -- while not desirable in large amounts in rations for poultry and hogs, is desirable in rations for cattle, sheep and horses. The digestive systems of poultry and hogs are unable to handle the bulky feeds that can be handled by ruminants and horses.

(e) Economy -- is important in all rations, but the cheapest ration fed is not always the most economical ration in the long run. The ration must be well-balanced to provide the required quantity and quality of nutrients.

In addition, the ration should be slightly laxative, plenty of good clean water should be provided, and succulent feed should be supplied.

10. What effects do common nutritional deficiencies have on farm animals?

Nutritional deficiencies in livestock result in great losses, not only to the owner but to the entire livestock industry. These deficiencies are not due only to the feeding of rations too low in one or more nutrients, but also due to insufficient feed. The latter, often called the "hollow-belly" deficiency, actually causes greater damage than the former.

Forced high production, and the feeding of grains and forages produced on nutrient depleted soils, have also created many nutritional problems. The increased confinement of livestock has further aggravated this condition. Under these unnatural conditions nutritional diseases and ailments have been on the increase.

The cause, prevention, and treatment of many of these results of nutritional deficiencies are known, but they continue to reduce profits because this knowledge is too seldom placed into practice. Often these deficiencies are of insufficient proportions to be easily recognized—they do not produce clear-cut deficiency symptoms. Therefore, they go unnoticed and unattended to, causing even greater economic losses.

Some of the most important nutritional diseases and ailments among farm livestock are rickets, bloat, vitamin A deficiency (example: nutritional blindness in cattle), iodine deficiency, phosphorous deficiency, X-disease, anemia, acetonemia, milk fever, grass tetany, founder, and salt deficiency.

11. What are the meanings, functions, uses, precautions and dangers of feed additives?

In recent years the use of feed additives in rations for various kinds of livestock has increased tremendously. These additives are generally classified into four groups:

(a) Hormones -- Many years ago scientists determined that many of the body processes of animals are controlled and regulated in varying degrees by substances called hormones. Certain hormones are produced by the ductless glands of the body as internal secretions which are discharged into the blood and distributed to the various parts of the body where they perform their functions.

Hormones are administered to animals as feed additives or body implants. They haven't yet generally proven to be of value in feeding livestock except in the case of beef cattle being fed for market. However, when administered to breeding stock, breeding difficulties may occur. Stil-

bestrol and Thyroprotein are two hormones being used.

(b) Antibiotics -- are chemical compounds that have the ability to inhibit the growth of, or even destroy, certain micro-organisms which may cause diseases. They also increase feed consumption of livestock by increasing the appetite. The following includes additional information concerning antibiotics:

(1) Suitable antibiotic feed supplements will generally increase appreciably the rate of gain in pigs, dairy calves, chicks, broilers, and poults, until about 3 months of age.
(2) In most cases, antibiotics will reduce very slightly the feed required per pound of gain (with the animals mentioned in No. 1).
(3) The feeding of antibiotics to sheep and beef cattle is still in the experimental stage, with considerable disagreement to date as to their value.
(4) It is usually unprofitable to add antibiotics to feed for brood sows, or for dairy cows, and dairy heifers 4 months or older.
(5) Many antibiotic supplements also contain B-complex vitamins. Some of the benefits may be due to these vitamins.
(6) Antibiotics probably stimulate growth primarily by (a) reducing the number of detrimental bacteria in the digestive tract of animals, and (b) increasing the appetite, and thus feed consumption, of farm animals.
(7) Some antibiotics have produced good results, and some have not. The reputation of the feed manufacturer is probably the best guide in purchasing formula feeds which contain antibiotic additives or supplements.

(c) Tranquilizers -- have been used for years in human medicine for the treatment of certain mental disorders, high blood pressure, nervous tension, etc., but during recent years some research has been devoted to determining their value in livestock production. However, at the present time, results are primarily in the experimental stage.

(d) Enzymes -- are organic catalysts whose function is to break down food so that it can be absorbed and used. The more efficiently food is broken down the greater the value of the feed. Enzymes are already present in an animal's digestive tract, but scientists are trying to determine if the addition of various enzymes to the ration will increase the efficiency of the ration. Different enzymes act upon carbohydrates, fat and proteins, to break them down.

Extreme care should be exercised in the use of feed additives. Their effect as of the present time are largely speculative. (This is especially true with tranquilizers.) Strict adherence to recommendations should be followed when they are used.

III. Environmental Factors That Affect Physiology

1. What effect do environmental factors have upon animal production?

a. Temperature -- All animals suffer when the temperature becomes excessively high or low. The different species of animals, as well as individual animals within these species, vary in their ability to withstand these extremes. Within the beef cattle breeds, the Brahaman and Santa Gertrudis withstand extremely hot weather better than do many of the other breeds. Among the European breeds of cattle the Brown Swiss, and Jerseys tolerate heat better than Holsteins, Ayrshires, Herefords, Aberdeen-Angus, or Shorthorns.

Extremely high temperatures may be a predisposing influence that results in lowered resistance to bronchial infection, reduction in appetite, an increased work load upon the heart, and otherwise directly or indirectly affect the health of an animal. There is good evidence that summer heat combines with heavy lactation to produce breeding problems.

Likewise, when the temperature becomes extremely low it can become a predisposing influence to lowered health. As the temperature becomes lower and lower, the production of heat within an animal's body must be increased. On cold days animals eat more heartily and usually exercise more than in warm weather, resulting in the production of more heat within the body. When an animal becomes too cold it begins to shiver. Actually, what is taking place is that the muscles are contracting involuntarily in order to produce more heat.

Well-fed animals can withstand lower temperatures than can poorly-fed animals, due to the greater fat content in the bodies of the better fed animals. And naturally, on the other hand, fat animals experience greater difficulty during extremely high temperatures than do animals that are not so fat. Artificially heated quarters are not needed for dairy cattle- at least in the Southern section of these United States. Similarly, cattle and sheep fattened in the winter in cold climates make economic gains when housed in open sheds, or even canebrakes- where quarters are fairly dry and free from excessive drafts.

Normally, very young animals need warmer quarters in colder weather than older ones. This is especially true with very young pigs and very young artificially raised chickens, who need artificially heated brooders. Very young calves, too, need reasonable warm quarters; however, young dairy calves, for instance, are successfully raised in Mississippi in individual calf pens. Under these conditions, unless extremely cold and extremely young animals are being dealt with, there is no need for artificial heat- only protection from rain, snow and cold drafts, and warm bedding are necessary.

During extended periods of extreme temperatures, especially high ones, milk yields are likely to be reduced, growing or fattening animals tend to make less rapid gains, and egg production among hens is lowered.

b. Light -- It is believed that bright sunlight may have some predisposing influence upon the incidence of cancer eye, pinkeye, and photosynthesisation in cattle. The length of the daylight period has an effect upon the egg production of laying flocks, and the production of broilers. For example, during seasons of short daylight hours, artificial lights are turned on during the pre-daylight hours in laying houses, and broiler houses. These light rays activate the pituitary glands of the chickens, causing hormones to be released into the bloodstream. This additional

supply of hormones results, if the bird is not already performing at full capacity- according to its ability- in increased production.

In addition, the value of light in aiding in the control of some diseases and parasites should not be under estimated.

c. Moisture -- Moisture content in the air can affect an animal's health and its production. For instance, high moisture-laden air (high humidity) does not cool an animal as rapidly as does air containing normal or low amounts of moisture. During high-temperature high-humidity periods perspiration from the body is not absorbed by the surrounding air to the extent that it is during periods when high-temperature low-humidity conditions prevail. Consequently, body temperature increases. Deaths from heat strokes have resulted from such conditions.

Air containing excessive amounts of moisture is capable of transmitting more contagious disease germs than can be carried by drier air. Diseases and parasites thrive better under damp, dark, warm surroundings. Likewise, damp air during cold weather predisposes the animal to respiratory ailments.

IV. Diseases of Farm Animals

1. What is a disease and how are diseases classified?

   a. Disease defined.*

   A disease may be defined as a disorder of mind or body marked by definite symptoms. It may be further defined as an alteration in the condition of the body or any of its organs that interferes with the normal functioning of the body or any of its parts.

   b. Diseases classified.*

   The classification of diseases, and examples of diseases coming under each classification are:

   (1) Communicable, or contagious-- These diseases are caused by germs or microscpoic living organisms that can be spread by direct or indirect contact from animal to animal. Blackleg, anthrax, brucellosis (Bang's disease), and leptospirosis come under this category.

   (2) Non-communicable, or non-contagious-- These are diseases usually caused by something other than germs, such as traumatisms, poisons, disturbances of metabolism, and faulty nutrition. Examples of non-communicable, non-contagious diseases are:

Traumatisms	Poisons	Metabolism disturbances	Faulty nutrition
Broken bones	Prussic acid	Milk fever	Vitamin A deficiency
Bruises	Chemical(insecticides,		
Lacerations(barb-wire injuries, etc.)	amm. nitrate, etc.)	Acetonemia	Calcium deficiency

   A few infectious diseases such as tetanus (lockjaw) and botulism (food poisoning) are non-contagious.

   * The definition of a disease as given here is rather broad in its meaning. Even though it may vary somewhat from a person's idea of the definition of a disease , this definition is one given and agreed on by many authorities.

2. What causes diseases in farm animals?

   a. Bacteria -- Bacteria, or germs, are microscopic organisms of various types and shapes found everywhere in nature. Some are beneficial or non-pathogenic types, such as bacteria that aid in the cheese ripening process, the vinegar fermenting process, the decaying of plant materials, etc. Some are disease producers, and are known as pathogenic bacteria.

   Pathogenic bacteria produce toxins, which are poisons produced by action within animal or plant tissue. These toxins are produced by two different types of processes: (a) Toxins produced within the bodies of pathogenic bacteria are known as endotoxin. These toxins are released with deadly effect when the pathogenic bacteria die and disintegrate. An example of an endotoxin disease is tuberculosis; and (b) the most

powerful type of toxin, known as exotoxin (or soluble toxin) are produced in the mediums in which they grow. The powerful, virulent toxins produced in this manner enter the body and cause enterotoxemia, tetanus (lockjaw), etc.

Certain types of bacteria produce localized inflammatory changes in tissues. An example is the abcess. These infections may remain localized or may enter the bloodstream and cause a serious general disturbance, and sometimes death from septecemia- "blood poisoning".

b. Protozoa -- Protozoa, one celled animals, cause such diseases as anaplasmosis and coccidiosis.

c. Viruses -- Filterable viruses also cause diseases. A virus is an infectious agent too small to be retained by filters that retain bacteria, and also too small to be seen under an ordinary high power microscope. Among the animal diseases caused by viruses are rabies, hog cholera, and foot and mouth disease. (Some virus diseases in man are small pox, influenza, infantile paralysis, and mumps.)

Viruses must be propagated through a host organism- media containing living cells. Many are propagated in growing chicken embryos.

Some of the virus diseases are complicated by the action of secondary bacterial invaders. A vicious cycle may be established by the virus and the secondary bacterial infection- the action of one increases the virulence or power of the other. This sometimes occurs in hog cholera, swine influenza, and distemper in dogs.

d. Mold and Mold-like Fungi -- Fungi, which are non-green plants, cause atheletes foot, ringworm, and some ear and eye infections. Most fungus diseases are confined to the covering of the animal's body, and are seldom fatal.

e. Parasitic Worms -- Internal parasitic diseases are caused by tapeworms, hookworms, roundworms, etc. Internal parasites are a universal hazard to livestock production. They are abundant in kinds and numbers, and losses are often unrecognized because animals often do not exhibit extreme signs of infestation.

f. Other Causes -- Other causes are foreign bodies and nutritional deficiencies. Foreign bodies such as nails, wire, etc., are taken into the digestive tract. Ruminating animals retain many such objects in their reticulum, or second compartment of their compound stomach. However, sharp objects may still endanger the animal's life. In non-ruminating animals the danger of swallowing these objects is greater than in ruminating animals, due to their not having a compartment in their digestive tract that has the function of the reticulum in the digestive tract of ruminants.

Nutritional deficiencies, whether the result of too little feed or unbalanced rations, are a great detriment to an animal's health. (Refer to II - Nutrition of Farm Animals- in this publication for information concerning nutritional deficiencies.)

Some people believe that heredity plays a minor role in pathology. Such reasoning is not based on facts, but there may be some indirect influence. Animals may have inherent resistance or a susceptibility to specific diseases; in other words, an animal may have a predisposing influence to some diseases.

Lethal, or deadly characters are heritable. Lethal traits bring about the early death of the young individuals. Some lethal diseases are the "bull dog" calf, which has a round vaulted skull, swollen tongue, swollen body, and short legs They are born dead and are not to be confused with "Acorn" calves, who resemble "bull dog" calves. "Acorn" calves are born alive, and the cause of their condition is not hereditary. Hairlessness, in some dairy calves at birth, is another example of many lethal

traits affecting livestock.

Inherited conditions in livestock that do not necessarily result in death of the individual are very numerous. However, such conditions do result in economic loss to the producer. Some of these conditions are dwarfism in cattle, extra or rudimentary teats, fused teats, blindness, etc.

3. What physiological changes indicate disease?

Physiological changes vary somewhat from disease to disease. However, any marked and persistent deviations from normal temperature, pulse rate, and breathing rate may be considered as possible signs of ill health.

In general, an increase in the body temperature of an animal ushers in an infectious disease. However, it must be remembered that normal temperatures may vary among animals slightly. Temperature is also affected by exercise, excitement, outside temperature, age, feed, etc. It is lower in cold weather, higher in extremely hot weather, lower at night, and in older animals. Temperature is even affected by inadequate supplies of water.

The normal pulse rate also varies from animal to animal. It will also vary with excitement, exercise, digestion and outside temperature.

The breathing rate is accelerated when the animal is suffering from pain or discomfort. Increases are also due to excitement, exercise, high temperature or poorly ventilated buildings.

Even though these physiological changes may be signs of ill health, they may also be due to the other reasons mentioned. Changes due to excitement, exercise, etc., should not be confused with disease.

In addition, other changes may consist of a decreased appetite, an undue thirst for water, a listless appearance, etc.

The following table gives the normal temperature, pulse rate, and breathing rate for several species of farm animals.

Animal	Normal Temperature*		Normal Pulse Rate	Normal Breathing Rate
	Average	Range		
	Degrees F.		Rate per Minute	
Cattle	101.5	100.4 - 102.8	60 - 70	10 - 30
Swine	102.6	102.0 - 103.6	60 - 80	8 - 18
Sheep	102.3	100.9 - 103.8	70 - 80	12 - 20
Goats	103.8	101.7 - 105.3	70 - 80	12 - 20
Horses	100.5	99.0 - 100.8	32 - 44	8 - 16
Fowl	106.0	105.0 - 107.0	200 - 400	15 - 30

* Rectal

4. What natural defenses do bodies have against disease?

An animal's body may be considered a battle ground in which the invading forces seek to overcome the defense. The body is equipped by nature to

fight against disease. Three lines of defense aid in the fight.

a. Defense line number one -- The function of this line is to prevent disease germs from entering the body. Skin, covering all exterior parts of the body, is bacteria-proof unless it becomes broken. However, it is not virus-proof, so we have very little protection against this group of disease germs entering the body. The body openings, lined with mucous membranes, serve as a protective lining. Other first line defenses include the acid of the stomach, and the tears of the eyes.

b. Defense line number two -- If the first line of defense is unsuccessful in preventing entry of the disease germs into the body, then the second line of defense, the white blood corpuscles of the bloodstream, go into action. If, for instance, disease germs enter through a break in the skin, these corpuscles immediately leave the blood vessels and proceed through the tissue fluids to the site of infection. They completely surround the invading germs and begin to engulf them. A race starts between the multiplication of the invading bacteria and their destruction by the white corpuscles. During this period of infection the involved tissues usually become swollen and inflamed. This inflamed, or red condition is the result of the increased flow of blood to the area to promote healing. The lymph also aid in this fight by carrying disease germs to nodes when they are filtered out and destroyed by white blood cells. Pus, which is dead bacteria and white corpuscles, collects at the site of infection. It is later discharged externally, or transmitted to the excretionary organs and discharged. During this struggle fever may arise. Fever is a body reaction against infection, and actually is beneficial unless it is too high during too long a period of time.

c. Defense line number three -- If the second line of the body's defense is unsuccessful in destroying the pathogenic organisms then they enter the bloodstream. The infection then becomes general and the patient begins fighting for his life. The infection becomes a battle between bacteria and their products and antibodies produced by the blood to destroy the bacteria, or at least to neutralize the effect of their poisons.

Another factor, general resistance, seems to play a vital role in maintaining the body defenses against disease. It performs a role in all three lines. A general healthy condition strengthens the body's resistance to pathogenic organisms, while a general unhealthy condition weakens its resistance to them.

5. What principles are involved in controlling diseases?

One or more of the principles of immunization, sanitation, and isolation may be involved in controlling diseases.

6. What is immunity and how is it acquired?

Immunity from a disease refers to the power of the body to resist a disease by natural or artificial means. Immunity may be natural, or it may be acquired. Some species of animals are immune to diseases of other species. In other words, they have natural immunity. For example, cattle are not susceptible to hog cholera. Acquired immunity is established during the life time of the individual. It may be permanent (active), or it may be temporary (passive), depending on the manner in which it is acquired. Permanent immunity from a disease results from having had that disease, or it may also be acquired artifically by using biological preparations such as vaccines, bacterins, etc.

Temporary immunity is acquired artificially through the injection of antibodies contained in serums and toxoids. For example, tetanus antitoxin

(or antiserum) is taken from the blood of the horse, processed, and injected into the blood of man or other animals to give immunity in the case of deep wounds. These antibodies remain only temporarily and when destroyed no longer make the inoculated individual immune.

In many instances serums, vaccines, and other immunizing agents (biological preparations) aid in the treatment and prevention of infectious diseases by bolstering the natural defenses of the body. (Refer to question number 4 on page 38.)

7. What are the characteristics of immunizing agents?

(a) Vaccines -- Vaccines contain modified, live or killed pathogenic (disease producing) virus or bacterial organisms in suitable media. Under certain conditions they are capable of producing the disease for which immunity is intended. Vaccines require 7 to 21 days after injection for the stimulation of satisfactory immunity, which lasts from 4 months to life. Repeated injections may be necessary. Rabies, distemper, anthrax and bang's vaccines are several of the well-known ones.

(b) Serums -- Serums contain no pathogenic organisms. They are the fluid part of the blood of hyper-immunized animals containing antibodies that will overcome neutralized, or destroy, disease producing organisms which stimulate their development. Immunity lasts from a few days to 3 weeks at most. Hog cholera serum is widely used.

(c) Bacterins -- Bacterins are suspensions of killed pathogenic bacterial organisms. Seven to twenty-one days are required to produce immunity that lasts from 4 months to life. Repeated injections may be necessary. Blackleg bacterin is one of the most widely used.

(d) Toxoids -- Toxoids are detoxified poisons. They were previously produced by pathogenic bacterial organisms. Toxoids require from seven to twenty-one days for the production of immunity that usually lasts for one year. Tetanus toxoid and Enterotoxemia toxoid are examples of this type of immunizing agent.

(Note: There are combination immunizing agents that can be administered. For example, there are combinations which can be given in one injection to stimulate immunity against one, two, or three diseases. The blackleg-hemorrhagic septecemia- malignant edema bacterin is a well known three-way combination. DO NOT COMBINE ANY IMMUNIZING AGENT WITHOUT THE ADVICE AND PRESCRIPTION OF A LICENSED GRADUATE VETINARIAN.)

8. How does sanitation relate to the spread and control of diseases?

Sanitation is synonomous with cleanliness, and cleanliness is basic in any program of disease or parasite control- both preventive and curative. The old adage "an ounce of prevention is worth a pound of cure" still holds true. Unclean, unsanitary premises breeds filth, and filth breeds disease and parasites. Sanitation involves general cleanliness including keeping the premises well drained, free of infected animals, animal body discharges, disinfection, pasture rotation, etc. No disease or parasite control is very effective that does not involve the continued use of sanitary measures. Sanitation plays an important role in the prevention of diseases by reducing the number of disease bacteria

on the premises where livestock are kept. It is especially important that strict sanitary measures be used on premises where contagious diseases are present, because sanitation plays an important part in preventing the spread of any infectious disease. It should be remembered that the number of disease germs gaining entrance to an animal's body determines to a large extent whether or not that animal contracts the disease, and if it does, the degree of mildness or severity of the disease.

9. How do isolation measures aid in controlling diseases?

Isolation, or quarantine, involves the separation of non-diseased animals from diseased ones, or disease exposed animals from unexposed ones. The principle governing effective isolation is that there must be no direct or indirect contact between the animal in isolation and those not so restrained. Isolation, of course, is an essential aid in preventing the spread of diseases or parasites.

Isolation has its variations depending upon the degree of contagiousness of a disease. For example, hog cholera spreads very rapidly, making isolation of considerable value in its control.

Isolation of newly purchased animals before they are placed with other animals already on hand is also an important phase of disease control.

In its wider application animals are isolated or quarantined, by law, to keep a disease from spreading to other counties, states, etc.

10. How are the various medications used in disease control applied?

Medications are applied by injecting them into the body by several injection methods. Other methods are also used, such as oral, topical (exterior surface), inhalation, and rectal.

Injections into an individual's body are made in several different ways- subcutaneously, intramuscularly, intravenously, and intraperitoneally.

A subcutaneous injection is an injection made beneath the skin. The areas of injection are places where the skin is loose, particularly on the sides of the neck, behind the shoulder, and in the axilliary spaces between the foreleg (armpit).

Intramuscular injections are made through the skin and subcutaneous tissue, directly into the muscle. Heavily muscled parts of the body such as the neck, shoulder and hindquarters are good areas for this type of injection.

Intravenous injections are made directly into the veins. This method is generally used when quick and effective action is necessary to save life.

Intraperitoneal injections are made through the belly wall. This area is the center of the area known as the "hollow of the flank". This type of injection is made in lieu of intravenous injections.

Oral administrations of drugs are given by the mouth and are absorbed in the stomach and intestines. Absorption is more rapid when drugs are given in solution into an empty stomach. They are absorbed slower when administered in powder, pill, or ball form, and on a full stomach.

The inhalation method is used when volatile drugs are administered for their local action in the respiratory tract.

Rectal administration is used when oral administration is impossible or inadvisable, due to paralysis of the throat, or other conditions. The absorption rate is slower.

Topical (external surface) applications are local applications made to external surfaces of the body. Absorption by this method is extremely slow. The effects of the drug are also limited to the local area.

(Note: For additional information including detailed sketches of administering drugs by various injection methods, refer to pp. 9-15 and pp. 76-77, 1961 issue of "The Globe Blue Book", published by the Globe Laboratories, Inc., 116 Commerce Street, Fort Worth 2, Texas.)

V. Common Parasites of Farm Animals (Economics)

1. What are parasites and how are they classified?

As used in this publication, the term "parasites" refers to low forms of animal life that live on or in other animals (hosts) larger than themselves— and at the expense of the host.

Parasites are classified as external and internal types. External parasites, such as fleas, ticks, and lice, live on the skin or in its layers. Internal parasites, such as cattle grubs, roundworms, etc., live in the digestive tract, the liver, the lungs, the kidneys, and elsewhere in the body.

2. What is the nature of the life-cycles of parasites?

Each of the many kinds of parasites have a relatively fixed life-cycle and rate of development, despite the abundance of different species, each of which has its own forms, habits, modes of life, and potentialities for causing disease and injury. This cycle involves a series of stages in the life history of parasites. In many parasites, the development from egg to adult includes several more or less distinct stages. This series of stages in a life history is called metamorphosis. Among insects there are basically six types of metamorphosis. However, most insects are classified into two of these types— complete metamorphosis and simple metamorphosis. Even though all species of parasites are not classed as insects, many of them are. Therefore, many common parasites of farm animals fall into one or the other of these two major metamorphosis types. (These two types, however, do not include such parasites as tapeworms, roundworms, etc. whose life cycles are not as well-defined as are the life cycles of parasites classified in the two major groups. Intermediate hosts are required for the completion of their life-cycles.)

Parasites having life cycles in which the young are not at all like the adults, as in the case of cattle grubs, are said to have complete metamorphosis. There are four stages in their lives: (1) the egg; (2) the larva; (3) the pupa, or resting stage; and (4) the adult. In others, the differences between their immature and adult forms are slight— as in the case of lice. Their life-cycle is one of simple metamorphosis, and there are only three stages: (1) the egg; (2) the nymph; and (3) the adult. The nymph usually looks like the adult, except for a few minor features such as being smaller in size, having no wings, and no reproductive structures at the time. In some instances the entire life cycle is spent in or on the host animal. In other instances, one or more stages of the life cycle is spent outside of the host animal, and in some instances a stage in the life cycle is spent in the bodies of intermediate hosts, thus complicating the problem of control. The latter, for example, is true with the stomach worms of swine. Stomach worm eggs are excreted with the droppings of swine. Insects feeding on these droppings eat the eggs, the eggs hatch, and then the tiny larvae bore through the intestine into the body cavity of the insect, where in the course of about a month they develop to a stage infective to swine. Hogs feeding on contaminated ground swallow the beetles. In the stomach of the hog, these parasites are then freed from the bodies of the beetles by the action of the digestive juices. The young worms then make their way into the mucous membrane of the stomach where they grow to maturity.

3. What is the economic importance of livestock parasites?

Parasites have played an important role in the history of civilization, because they cause many of the ills to which human beings and animals are subject.

The value of livestock and poultry lost per year is approximately one billion dollars. Diseases and parasites alone are responsible for approximately one-half of these losses. All these losses are not confined strictly to farm operations, although losses discovered after livestock and poultry leave the farm have a way of being reflected in prices received by farmers. Hidden losses from disease and parasites in meat, hides, edible offal, and by-products, because of condemnation or lowered quality, when added to the economic loss from death and sickness on the farm, and between the farms and the processor, reach a staggering total.

4. What are the principles involved in the control of common parasites?

Parasites, and parasitic diseases as well, are of a nature that sets them apart and is the basis of special principles that determine and explain the measures used to control them.

Parasites are a universal hazard to livestock and livestock production. Climate, the kind of animals- susceptible to specific parasites, and other factors, determine their distribution.

Control of parasites usually means establishing control within an individual or within an individual herd or flock. Yet, in its broad meaning, control actually means complete eradication. However, as used in this publication, these two terms infer two different degrees of control. In other words, control, as used herein, refers to control in the individual animal or herd, while eradication refers to stamping out the infestation within a given state, or nation. If control measures are applied strongly enough, eradication of specific parasites can be achieved, however remote the possibilities.

The development of control measures requires the knowledge of certain facts relative to:

a. the manner in which a parasite propagates
b. the stage at which it is infective to its host (livestock and poultry)
c. the ability of the parasite to maintain itself for periods of time away from the host- on pastures, etc.
d. the condition under which the hosts become infected
e. the behavior of the parasite in the body of the animal, and the damage it inflicts,
f. the stage or stages during the life cycle of the parasite that are most vulnerable to attack.

Unless the farmer has a knowledge of these facts he can do little to overcome such pests.

Control methods are based on two keystones- sanitation and medication.

(1) Sanitation.

The adage "an ounce of prevention is worth a pound of cure" holds a lot of truthful meaning in a livestock and poultry parasite control program. That "ounce of prevention" actually refers to sanitation- the really basic measure of the two keystones. In other words, the key to prevention is sanitation.

Sanitation is a two-fold problem. There is, first of all, the problem of providing facilities and surroundings which can be made sanitary. Then there is the problem of keeping animals and their surround-

ings in a sanitary condition. Sanitation is, of course, dependent upon the solution of both of these problems.

Sanitation means cleanliness, and cleanliness, in a parasite control program, is the result when the following practices, among others, are observed:

a. The premises are kept free of general filth, trash, droppings, etc.
b. Dead animals are properly destroyed.
c. Premises, and animals when necessary, have been disinfected.
d. The animals have been moved to clean pastures as the old pastures became infected.

(2) Medication.

Few parasites have been controlled by medication alone, but in many instances medication, or the use of antiparasitic chemicals (including insecticides in some instances) are powerful aids to control. They are not synonymous with control or substitutes for it. Chemical measures generally are immediate in their effects, economical and simple. Some efficient measures of control do not depend for their success on the use of medication. For example, this is true in the case where the sanitation systems are used to control worm parasites in swine. Parasitism is essentially a herd or flock problem, rather than one of individual animals. The urgency of treating all animals of a flock or herd is dictated by the fact that parasitism is recognized first on one, or a few, animals when actually all the animals are probably infected. Measures of control, whether medication or sanitation, are really less effective unless they are applied to an entire herd or flock as if they were only one individual. Actually, in most instances both medication and sanitation are needed for control.

The concept of control of a parasite embraces all measures, the two basic ones as well as others, aimed at the weakest link(s) or stage(s) in the life cycle of the parasite. In other words, during certain stage(s) in the life cycle of a parasite, the parasite can be destroyed easier than in other stage(s). This is known as the "life-cycle approach". A concerted attack on all fronts achieves best results, but the strongest attack must be made on the parasite's stage(s) of development that is most vulnerable- "the weakest link", whether it be the larva stage, the adult stage, or some other stage.

The common roundworm, for example, is more vulnerable to attack during its adult stage in life, where-as the very effective control of screwworms has been accomplished by a radiobiological attack on the egg stage and also on the reproductive potential of adult flies.

Time factors have a great significance in determining when, how often, and at what intervals medication can best destroy the parasite. For instance, swine are treated twice at an interval of 10 weeks to combat large roundworms. The first treatment kills most of the worms present, while the second treatment destroys the worms that later hatch from eggs present at the time of the first treatment. Temperature, precipitation, and the other factors of climate determine the distribution, seasonal occurrence, and abundance of many parasites. Warmth and moisture generally favor their development. Many internal worm parasites must overwinter in animals because the free-living infective stages cannot survive the cold winter on pastures. They can be destroyed by medication during this winter period. External parasites, however, usually exhibit the opposite pattern. Lice, for example, survive in small numbers in the summer, but become abundant in the winter. It is quite easy to

control them by efficient treatment of animals in early fall.

Improper feeding and grazing, overstocking, unsanitary conditions, and inattention to illnesses in early stages favor parasitism. On the other hand, good feeding and the removal of adverse influences increase the resistance to the invasion and establishment of parasites.